LEGACY

The Official Newsletter of the Amaranth Institute

Volume IV 1991 No. 1

ENDORSED BY THE INSTITUTE FOR THE DEVELOPMENT OF AMARANTH PRODUCTS, INC.

From the Amaranth Institute President:

AN INTERNATIONAL CROP

Peter Kulakow, Plant Breeder
The Land Institute
2440 E. Water Well Rd.
Salina, Kansas 67401

While most members of the Amaranth Institute reside in the United States of America, I find it very encouraging to remember that amaranth is truly an international crop with original roots in North and South America and promising seeds that spread to Asia, Africa, and Europe. The Fourth National Amaranth Symposium held in Minneapolis, Minnesota last August helped highlight international developments with amaranth. There were representatives from at least ten countries. Developments in the USSR and China are noteworthy because of their rapid increase in the scale of amaranth production. Renewed interest in the amaranth in the USSR and China was inspired by work at the Rodale Research Center and the travels of the late Robert Rodale. I had the opportunity to tour the Minnesota State Fair with Dr. Ischan Magomedov of the University of Leningrad, who now heads a research team of over 100 scientists working on amaranth production in the USSR. Over 100,000 hectares (247,000

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Announcing the

FIRST INTERNATIONAL AMARANTH CONGRESS

Oaxtepec, Morelos, Mexico
September 22-28, 1991

This fall seven Mexican organizations are cosponsoring the First International Amaranth Congress. Their stated objectives are to i) exchange information concerning the most recent advances in diverse areas of amaranth research, ii) establish contact among different international research groups and institutions, and iii) to create an international network of researchers in amaranth.

The contact address for the Congress is: Programa Universitario de Alimentos. Coordinacion de la Investigacion Cientifica. Cd. Universitaria 04510 Mexico, D.F., Telephone: 550-58-23 or 550-52-15 Ext. 4812. FAX: 550-09-04. Details are also available from the Amaranth Institute Office: (507) 653-4379.

IN THIS ISSUE

LIPIDS OF GRAIN AND FERAL AMARANTHS

James W. Lehmann
IDAP, Inc., Bricelyn, MN 56014

Lipids are chemical compounds composed primarily of carbon, hydrogen, and oxygen and include fat, fatty acids, fatty oils, waxes, sterols and esters of fatty aids. Some lipids such as linoleic acid must be supplied to the human body. The high energy content of some dietary lipids is well known, especially when the body stores fats as adipose tissue. ther bodily uses of lipids include: aiding the digestion of other nutrients such as fat-soluble vitamins, serving as prostaglandin (a hormone-like substance) precursors, and playing a role in the organization of membranes.

Although not primarily viewed as a source of lipids, grain amaranths contain roughly 5-9% lipids (Garcia et al., 1987; Carlson, 1979). Compared to most cereals except millets, amaranth lipids are present at somewhat high levels (Lorenz and Hwang, 1985) (Table 1). Lipids are concentrated in the seed coat/germ fraction (Becker et al., 1986). The early lipid literature on amaranths has been summarized (Saunders and Becker, 1984; Singhal and Kulkarni, 1988). Becker (1989) has reviewed the nutritional implications of amaranth seed oil.

The percent unsaturation in amaranth fats is reported as 65% by Opute (1979), as 74% by Lorenz and Hwang (1985), and as 76% by Saunders and Becker (1984). These levels are comparable to those of cottonseed and rice bran oils. Opute (1979) suggested that a high percentage of unsaturated fatty acids aids seed lightness and dispersal. Bertoni et al. (1984) also suggested the presence of a 16:3 component and their ultraviolet investigation concluded that β-eleostearic acid was present (0.4-0.6%). Crude fat levels of various amaranths are summarized in Table 2. Fernando and Bean (1985) compared the fatty acid composition of six amaranth species, including A. hybridus and A. tricolor, and concluded that the ratio of saturated to unsaturated fatty acids was fit for human consumption. A. cruentus oil was less digestible than cottonseed oil (Garcia et al., 1987). Singhal and Kulkarni (1990) found that puffing resulted in A. cruentus oil with decreased unsaturated fatty acids.

The unsaponifiable fraction of three grain amaranth seed oils (Seldes et al., 1987) yielded "C_{28} - and C_{29}-delta^7 sterols with saturated and unsaturated side chains as the main components and traces of cholest-5-en-3β-ol." These levels of unsaponifiable materials are very high (Bertoni et al., 1984). Garcia et al. (1987) suggest that the high unsaponifiable fraction as reflected in the somewhat low saponification number may reflect the presence of squalene or wax. Indeed, they noted a wax-like, amorphous solid in amaranth oil stored at 4^0 C. for 5 days.

Following hexane extraction of milled A. cruentus seed, Lyon and Becker (1987) refined and bleached the oil. Oil from A. hybridus, the progenitor species of grain amaranths, was a yellow color with a specific gravity of 0.847 (Batra et al., 1983). Historically, edible cooking oils were rarely used in pre-Conquest Mexico, the center of origin of the grain crop; instead, another crop called chía(n) (Salvia hispanica L. [Lamiaceae or mint family]) was used to prepare non-edible oils for paint (Soustelle, 1955).

The squalene (2,6,10,15,19,23 - hexamethyl-2-3,10,14,22 -tetracosahexane) content of amaranth oil is high among plant oils, comprising 1/400 of the seed weight or 5-8% of the seed oil (Lyon and Becker, 1987).

Table 1. Oil content of cereal grains.[1]

CEREAL OR GRAIN	OIL CONTENT (ether extract) %, dry basis
Amaranth	7.2
Barley	2.1
Corn (dent)	4.4
Millet	4.4
Oats	5.1
Rice (with hulls)	2.1
Rye	1.8
Sorghum	3.4
Wheat (hard)	1.9

[1] Data from Garcia et al. (1987) and National Academy of Science (1969).

Table 2. Crude fat levels of *Amaranthus* spp.

SPECIES	Crude fat (%)	Reference
Amaranthus arthropurpureus	9.8	Opute, 1979
A. caudatus	6.7	Garcia et al., 1987
	11.6-12.5	Bressani et al., 1987
	9.6	Bertoni et al., 1984
A. cruentus	7.9	Shephard et al., 1988
	7.9	Garcia et al., 1987
	9.2-12.8	Bressani et al., 1987
	7.0-7.8	Lorenz and Hwang, 1985
	7.7-8.0	Becker et al., 1981
	7.9	Ayorinde et al., 1988
A. edulis	8.1	Becker et al., 1981
A. gracilis	6.1	Singhal and Kulkarni, 1988
A. hybridus	6.4	Batra et al., 1983
	11.0	Opute, 1979
	6.5	Lorenz and Hwang, 1985
A. hypochondriacus	7.1	Garcia et al., 1987
	7.7-10.6	Bressani et al., 1987
	7.5-7.8	Lorenz and Hwang, 1985
A. paniculatus	6.9	Singhal and Kulkarni, 1988
A. polygamous	5.2	Singhal and Kulkarni, 1988
A. spinosus	6.0	Singhal and Kulkarni, 1988
	17.0	Opute, 1979
A. tenuifolius	19.3	Singhal and Kulkarni, 1988
A. tricolor	10.0	Opute, 1979
A. retrofexus	7.0-8.0	Christensen and Miller (1941); Wehmer (1929); Fursaer (1934); Tkachuk and Mellish (1977).

Olive oil is another squalene source (Auguet et al., 1988). Currently, squalene is extracted from whale and shark liver oil and is an cosmetic ingredient and skin penetrant as well as a lubricant for computer discs. Japan and Norway currently refine squalene and control the world's supply. In 1990, the U.S. market alone for squalane (the hydrogenated form of squalene) was expected to reach 66,200 lb./yr. The Japanese firm, Nippon Petrochemicals, has opened a $2.3 million, 1,000 metric ton/yr plant to process squalane from Asian shark liver oils (Anonymous, 1987). Ayorinde et al. (1988) and Lyon and Becker (1987) tested squalene content of vegetable and grain types of *A. cruentus* and found 3.2% and 8.0%, respectively. Singhal and Kulkarni (1990) increased the squalene content of *A. cruentus* oil to 15.5% by puffing.

The acid value of three amaranth oils was 15-24, as compared to soybean, corn, or cottonseed oils, 1-5 (Garcia et al., 1987). High acid value denotes the presence of free fatty acids. It is unclear whether high levels of free fatty acids (FFA) will cause rancidity problems in stored grain. By contrast, Ayorinde et al. (1989) found low or insignificant FFA levels in various amaranth varieties as showing low or a lack of lipase activity.

The tocopherol fraction of amaranth oil contains important cholesterol-lowering agents, some of which could be useful in treating cardiovascular disease (Qureshi, personal communication, 1989). Hypocholesterolemic (cholesterol-lowering) effects of dietary amaranth were suspected in some animal tests (Danz and Lupton, 1988). Brown and Goldstein (1980) suggest that squalene, another potential cholesterol regulator, is probably not the key regulator during cholesterol synthesis in the body.

Xu et al. (1986) surveyed the sterol composition of seven amaranth species including 4 varieties of grain amaranths. They determined that spinasterol was the major sterol in all grain species, followed by 7-stigmasterol, stigmasterol, 24-methylenecycloartanol, 7-ergostenol, campesterol. Some cholesterol (0.6 to 8.7% of total sterols) was found in two samples of *A. caudatus*, the South American grain amaranth.

Dixit and Varma (1971) identified β-sitosterol as a crystalline component of the unsaponifiable portion of A. caudatus lipids (See also Satyavati et al., 1976). Incidentally, USDA researchers have announced that rice bran oils with β-sitosterol and cholesterol compete for absorption in the intestines, thus decreasing cholesterol absorption (Anonymous, 1989).

Fernando and Bean (1984) investigated the sterol content of A. tricolor (a vegetable species) seeds and vegetative parts. They found five sterols present: stigmasterol, delta^{-7} ergosterol, spinasterol, delta^{-7} stigmastenol, and 24-methylenecycloartanol. No cholesterol was detected in any of the plant parts. In a comparison of the sterols in five species of amaranth, including A. hybridus and A. cruentus, Fernando and Bean (1985) found very similar sterol profiles relative to their 1984 study. Again, no cholesterol was detected in any sample and total sterol weight ranged from 0.22 to 0.36 mg/g dry weight.

Chadoeuf-Hannel and Taylorson (1987) monitored the fatty acid composition of germinating A. albus seeds. They discovered that seeds irradiated with red light showed an increase in unsaturated fatty acids. In another plant physiological study, Knacker and Schaub (1984) confirmed a relationship between palmitic acid, phosphatidylglycerol and the formation of photosynthetic "light-harvesting cholorphyll a/b protein complexes" in A. cruentus leaves.

Bressani et al. (1987) tested fourteen grain amaranth selections encompassing four species and found no significant differences in fat content among the selections. Fat content was not affected by fertilization. The essential fatty acid, linoleic acid, varied from 38% to 58% of the fatty acid content.

Table 3. Ranges of saturated and unsaturated fatty acids in four amaranth studies.

FATTY ACID	Content Range (%)			
	Bressani et al. 1988	Lorenz & Hwang 1985	Fernando & Bean 1985	Lyon & Becker 1987
Saturated fatty acids				
myristic (C14:0*)	Trace to 0.88%	0.1-1.2	0.05-0.01	----
palmitic (C16:0)	16.8-23.8	19.4-20.7	7.0-11.0	13.4-13.9
stearic (C18:0)	1.9- 4.0	3.9- 4.6	1.1- 2.0	2.6-2.7
Unsaturated fatty acids				
oleic (C18:1)	20.3-35.5	23.8-35.0	9.0- 9.7	19.8-20.4
linoleic (C18:2)	38.3-57.9	38.0-48.4	21.0-23.4	62.0-62.1
linolenic (C18:3)	1.0-3.2**	0.9- 1.2	0.3- 0.5	1.1
arachidic (C20:0)	---	---	0.3- 0.4	0.6 -0.7
lignoceric (C24:0)	---	---	0.2- 0.3	---

* C14 represents a chain of fourteen carbons; the second number represents the degree of unsaturation or number of double bonds.

** Includes C20:0.

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acres) of amaranth were grown in the USSR in 1990 for forage production. Apparently amaranth is able to fill an ecological role in many regions of the USSR where other forage crops were not successful. Dr. Magomedov was very optimistic about the future of amaranth in the USSR.

There were four scientists from China at the Minneapolis meeting with the delegation headed by Dr. Yue Shaoxian of the Institute of Crop Breeding and Cultivation for the Chinese Academy of Agricultural Sciences. Over 26,000 hectares (64,000 acres) of amaranth were produced in 1990 primarily for pig forage (Shaoxian and Honglinag, 1990). The Chinese, however, see a diversity of potential uses for amaranth including its use to make soy sauce without chemical pigment additives. Amaranth is particularly promising for non-irrigated acreage (50% of Chinese agriculture) and saline-alkali soils (over 17 million acres) in China. Amaranth has been tested in many ecological zones in China with variable but usually promising results. Most of the varieties tested come from the Rodale Research Center with lines R104, 1023, and 1024 figuring prominently in the tests. The highest grain yields were about 5000 lbs./acre with many locations yielding over 3000 lbs./acre. Fresh stem and leaf weights generally ranged from 80,000 to 134,000 lbs./acre. They found amaranth required about 3/5 the amount of water compared to corn sown at the same date. The root system of Rodale line 1024 had a rooting depth of 8 feet and produced over 128 miles of roots. This very likely contributes to the drought tolerance of amaranth.

Looking at amaranth from a whole farm perspective, Dr. Yue Shaoxian concluded amaranth would be useful for soil improvement and improved nutrient cycling in farming systems. For example, previously uncultivated saline and sandy soils could be rotated to wheat and soybean after 2-3 years of amaranth cultivation. In another region of continuous wheat production, amaranth could be grown during the 3 month fallow period and without irrigation could yield over 50,000 lbs./acre of forage after 70 days. Application of the increased manure generated by feeding this forage to pigs and sheep increased wheat yields 1 to 2 times. On the economic side, the ratio of capital invested to production value for amaranth was 6 to 8 compared to only 3 to 5 for most common crops.

More information on amaranth production in China and other information exchanged at the Fourth National Amaranth Symposium is available in the proceedings of the conference. These can be purchased from the Amaranth Institute (see announcement in this Legacy).

On a more local scale, we are planning for the Annual Meeting of the Amaranth Institute at the Fort

(continued on p. 7)

Table 2 Crude fat levels of

(continued from p. 6)

Sidney Motor Hotel in Sidney, Nebraska from the afternoon of August 16 through the morning of August 17, 1991. The meeting's theme this year is Amaranth Production in the 1990's. This meeting will be a good time for all of us in amaranth production, processing, marketing and research to get together for discussions. Saturday afternoon on August 17 we will tour amaranth fields on several Nebraska farms and the University of Nebraska Experiment Station in Sidney. Registration information will be mailed early May. We plan to have a poster session at the meeting. If you would like to present a poster please contact Peter Kulakow. For more information on the annual meeting contact Dave Baltensperger, (308) 632-1230, or Peter Kulakow, (913) 823-5376.

One final note, if you are presently conducting any aspect of research with amaranth and you would like to let others know what you are doing, I would like to present a brief summary of present research with amaranth at the annual meeting. If you would like to summarize your work with amaranth, even in a brief note, I will compile the information and present it in August. You can write me at The Land Institute, 2440 East Water Well Rd., Salina, KS 67401.

Reference:

Shaoxian, Yue and Sun Honglinag. 1990. The research and development of grain amaranth in China. p. 171-178. In Amaranth: Perspectives on Production Processing and Marketing. Proc. 4th National Amaranth Symp. Aug 23-25, 1990, St. Paul, MN. Minneapolis, MN.

RELEASE OF PLAINSMAN (P.I. 538322) GRAIN AMARANTH

David D. Baltensperger
Panhandle Research and Extension Center
Nebraska Agricultural Experiment Station
University of Nebraska-Lincoln

The Nebraska Agricultural Experiment Station and Rodale Research Center agree to release a new grain amaranth variety to certified growers. Plant Introduction (P.I.) 538322, also known as K343, will be released as '*Plainsman*'. *Plainsman* was developed cooperatively by the Rodale Research Center and the Nebraska Agricultural Experiment Station.

Plainsman originated from a cross between RRC1024 (P.I. 477917) and RRC1004 (P.I. 540446) made in 1977. RRC1024 is a gold seeded Amaranthus hypochondriacus accession from a cultivated selection that originated from a Mexico. RRC1004 is a black seeded A. hybridus accession from a cultivated selection collected in Pakistan. The pedigree method was used to develop a uniform population with single plant selections in the F_2 to F_5 generations, and mass selections in the more advanced generations. Based on floral morphology *Plainsman* would be classified as A. hypochondriacus.

Plainsman was selected for its earlier maturity, lighter seed color, and shorter plant height compared to its grain amaranth parent, RRC1024. In evaluation trials at the High Plains Agric. Laboratory in Sidney, Nebraska, *Plainsman* is one of the earliest maturing grain amaranth lines, requiring about 110 days to mature. RRC1024 is a long season accession which does not mature in western Nebraska. When moisture conditions are not limiting, *Plainsman* reaches an intermediate plant height of 1.6 m, whereas RRC1024 can grow to 2.2 m.

During the juvenile stage, *Plainsman* has a red leaf marking in the center of its leaves which fades as the plant approaches its reproductive phase. *Plainsman* develops a red upright flower and produces white seed. Compared to A. cruentus, or MT-3, *Plainsman* maintains better stem strength after frost.

Plainsman is a widely adapted cultivar. It has been grown successfully as K343 from North Dakota to Missouri. It was evaluated in amaranth variety trials and in farmer's fields in the Great Plains from 1986-1990. Yields have averaged more than 600 kg/ha.

The generation sequence of seed production will be breeder, foundation, registered, and certified. This cultivar will not be protected under the Plant Variety Protection Act. Breeder seed will be maintained by the University of Nebraska Agricultural Experiment Station, Panhandle Research and Extension Center. Foundation seed will be available from the Foundation Seed Division, 3115 N. 70, Lincoln, NE 68507-0913.

Small Business Innovation Research Program

This Federal program grants money for technological D4 innovations. Funds are available to study either feasibility or development of innovations. Feasibility grants are up to $50,000. Development grats are up to $250,000. Some Amaranth businesses could qualify. Questions and requests for proposal instructions should be dircted to:

Dr. Charles Cleland
SBIR Coordinator
Cooperative State Research Service
U.S. Department of Agriculture
Room 323 Aerospace Building
Washington, D.C. 20250-2200
Telephone (202)401-4002

New Book Includes Amaranth Information

Facciola, Stephen. 1990. Cornucopia: A Source Book of Edible Plants. Kampong Publications, Vista, California. This compendium lists 47 Amaranth cultivars, all with commercial sources. They are divided into grain and leaf types.

Amaranth Periodicals

In addition to Legacy, two other Amaranth periodicals are available.

The Amaranth Newsletter is published in both Spanish and English. It is available from Archivos Latinamericanos de Nutricion, P.O. Box 1188, Guatemala City, Guatemala, C.A.

Amarantos Novedades e Informaciones is published in Spanish. It is available from Facultad de Agronomia de la Universidad Nacional de La Pampa y Estacion Experimental Agropecuaria Anguil, La Pampa (INTA), R. Argentina

Manuscripts and information for publication in Legacy are welcome, and should be sent to David Brenner, Plant Introduction Station, Iowa State University, Ames, Iowa, 50011 USA.

Proceedings of the Fourth National Amaranth Symposium

A few copies of the 200 page manual of current literature and perspectives are still available (at cost) from the Amaranth Institute.

Errata

Lipid Bibliography--Singhal, R.S., and P.R. Kulkarni. 1988. Review: Amaranths--An underutilized resource. Int. J. Food Sci. Technol. 23:125+.